CHAPTER 3

# Technology and the American Economy

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*As new types of information technology link together computers, telephones, and other types of communications devices, network effects become increasingly important in determining the success or failure of some products. In industries not subject to network effects, the total value of a product is simply the sum of its value to each user. But in industries where network effects are present, such as telephone or Internet service, the more links the network has, the more valuable it is to each participant in the network.*

Over the last century, the American economy has adapted again and again to continuing technological change. Repeatedly during our history, American firms and workers have exploited opportunities inspired by a succession of technical advances, in the process creating new products, new services, and even whole new industries. The new ideas that have reshaped individual industries have often had a broader effect on the economy as well. Innovation makes it possible to produce more output from society's available labor and capital, increasing the productivity of America's workers. Those productivity improvements have led to rising prosperity and living standards, as Chapter 2 discussed.

Innovations during the 20th century have led to dramatic changes in how firms compete in the American economy. In some cases, new technology has given birth to new markets, where startup companies compete on equal terms on a fresh and level playing field. In others, it has opened a door for entrepreneurs to enter older industries and challenge the established incumbents. As these forms of competition have spread and flourished, consumers have benefited in numerous ways, from expanded service, greater variety, and falling prices. These gains come not just from the new entrants but also from the old incumbent firms, forced to respond to the economic challenges posed by their rivals.

Today, new technologies are transforming the economy. No one can yet predict all the changes to come, but it seems clear that the information economy is changing the way companies compete and the nature of work. In addition to changing the competitive playing field, technology is increasingly redefining the role of the firm. Some firms are expanding to take on new roles and integrate new activities into their enterprise, some are finding it efficient to outsource some of their activities to specialists outside the firm, and some are restructuring through mergers and acquisitions. Two industries where these trends are strikingly evident are telecommunications and information technology; this chapter will look at both these industries, in which many firms, old as well as new, are exploring the economic opportunities made possible by innovations in computers, communications technology, and the Internet.

Although technological innovation brings constant and ultimately beneficial change to the economy, it also requires a constant reevaluation of government policies to determine how best to shape the forces of change to promote the public interest. As technology becomes increasingly vital to our knowledge-based economy, a crucial task of government is to design an appropriate technology policy to maintain the flow of new ideas, products, and methods that sustains long-run growth.

One element of technology policy is government's role in creating but also limiting the property rights of innovators. Without the intellectual property rights provided by patents and copyrights, for example, the reward to innovation in many fields would fall, as imitators quickly develop similar products. Yet strong property rights for innovation can also create barriers to entry and competition, hampering not only the mere imitators but also the true innovators seeking to build on the existing knowledge base. This problem becomes particularly acute as knowledge-based industries, such as software and information technology, grow in economic importance.

A second element of technology policy in today's economy is supporting the research and development (R&D) necessary to innovation. Although the private sector in recent years has increased its R&D expenditure, some of the basic and applied research that forms the building blocks for tomorrow's discoveries may not take place without government support. Rather than support technologies that have clear and immediate commercial potential (which would likely be developed by the private sector without government support), government should seek out new technologies that will create benefits with large spillovers to society at large. Basic research that expands human knowledge is one example of the type of research that may have wide applications in many areas of the economy. By supporting the research necessary for scientific advances, government funding can create the knowledge from which will emerge the new technologies, new products, and new jobs of tomorrow's economy.

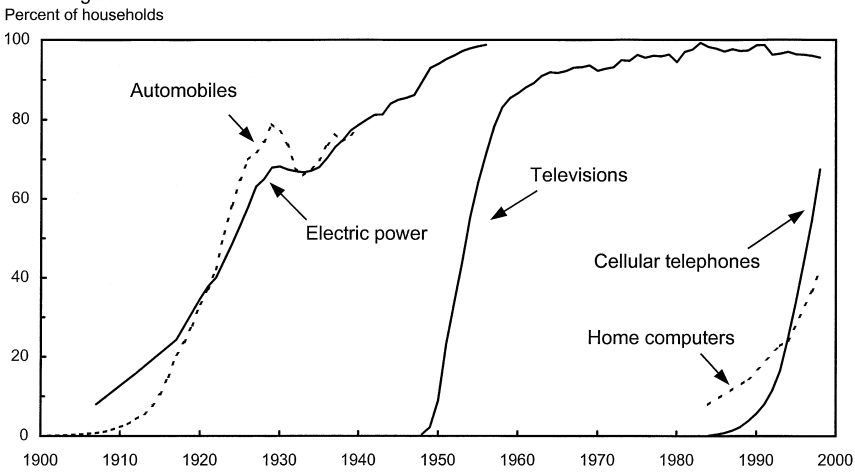
Another critical task for government is to ensure that the benefits of new technologies are widely shared. Well-functioning markets inherently maximize the private benefits from exchanges between individuals and firms, but markets do not always succeed in maximizing social benefits at the same time. Inefficiencies in the market, whether created by insufficient R&D incentives or from a firm's market power, can limit the gains society receives from technological innovation. One way to promote the widespread adoption of innovations is to ensure that policy set by the public sector fosters rather than stifles competition in the private sector. Antitrust policy is one tool for encouraging competition. When the Nation's antitrust laws were originally adopted, market power created by economies of scale in the production of many industrial goods was a major concern, but in today's economy the market power inherent in products that become de facto standards for an industry may be just as troubling. In addition to a vigorous antitrust policy, government can promote competition by changing the regulatory framework within which industries operate, to remove barriers to competition and spur innovation, thereby creating jobs for American workers and new services for American consumers.

In other areas of the economy, such as the rapidly developing field of e-commerce, the challenge for government policy is different. Here new businesses are springing up spontaneously, and at an explosive pace. By refraining from imposing unnecessary regulatory burdens, government can ensure that innovative and valuable services will come to market. Government antitrust enforcement will continue to ensure that mergers between large firms deeply involved in the information economy will not injure competition.

## Innovation and Economic Change: A Look Back

The changes that technology continues to unleash on our economy today are sweeping and may at times seem overwhelming. No one yet knows what transformations the Internet and e-commerce, to take only the currently most celebrated examples, will eventually bring. In these circumstances we should remember that we are not the first generation to have to come to grips with rapid technological progress. Notable examples of the rapid adoption of new innovations include electric power, automobiles, and television. These earlier innovations spread through American households much as have more recent innovations such as computers and cellular telephones (Chart 3-1). As described below, throughout the 20th century new technological developments created new products and new ways for firms to conduct business, and so changed the structure of the economy. Those changes, in turn, produced changes in the role of government in competition, regulatory, and technology policy.

Chart 3-1 **Household Adoption of Selected Technologies Since 1900**
The rapid adoption of computers and cellular phones today has its parallel in earlier technologies.




Note: Automobile and cellular phone adoption are estimated by dividing the number of registrations and subscriptions by the number of U.S. households. Unlike the survey data used in the other series, these numbers will overstate actual adoption when households register multiple cars or purchase multiple cellular subscriptions.
Sources: Department of Transportation; Department of Commerce;Television Bureau of Advertising Inc.; and Federal Communications Commission.

One example, electricity, is a commonplace fixture in the economy of today, but in 1900 the electric power industry was just getting under way. At the turn of the century, fewer than 10 percent of homes had electric service, and cities were still being wired for electric transmission grids powered by central generating stations. At that time, only about 5 percent of factories employed electricity as a power source; most still used steam or water power to drive their machines through intricate arrangements of wheels, belts, and shafts. Electricity was initially used to power similar systems, but the shortcomings of mechanical power distribution systems remained. Once factory workplaces were reorganized so that groups of machines could be separately powered by electric motors, however, manufacturers began to realize the full potential of electricity to improve productivity. Over time, electric power was incorporated into more and more elements of the modern factory. Some have argued that the process may be repeating itself today with computers. As modern businesses learn to use computers to change the way they operate, they can find new ways to optimize business procedures and increase productivity.

At other times during the century, technological advances in basic industrial products such as oil dramatically increased productivity and output, by expanding the scale at which firms could operate their plants. But some of the largest firms also formed combinations, like the Standard Oil trust, to limit competition. Concern about the market power of some of these large new industrial combinations led to passage of two of the cornerstones of public policy toward competition. The Sherman Antitrust Act (passed in 1890) governing anticompetitive actions by monopolies and the Clayton Act (passed in 1914) governing mergers remain the basis of antitrust law today.

The automobile, too, had made its appearance by the end of the 19th century, but it remained a high-priced luxury item until Henry Ford built the first automobile assembly line in 1913. Ford's innovation revolutionized the way cars were manufactured. Mass production of the Model T allowed Ford to offer, on an unprecedented scale, a product that combined relatively high quality with a dramatic reduction in cost. It made automobiles available to millions of American consumers for the first time. As increasing numbers of people bought the newer, cheaper cars, Ford continued to invest in his factories, increasing their efficiency and realizing huge economies of scale. Greater scale, in turn, allowed Ford to lower the cost of his automobiles still further and sell even more. By the early 1920s the Ford Motor Company dominated sales of automobiles in the United States, with a market share of 56 percent. Ford's dominance was short-lived, however, as other manufacturers, with newer models and innovations of their own, adapted their production processes following Ford's example. They were able to effectively compete with Ford by satisfying consumer demand for variety. Ford's innovation had a number of implications far beyond the automotive industry: it helped make America a more mobile society, for example. But perhaps the most important outcome for the economy as a whole was that other manufacturers in other industries soon copied the assembly line concept. The impact of this spillover from Ford's idea to other industries was enormous: mass production proved an economically efficient way to produce a vast range of other consumer products.

Another industry that saw major changes at the turn of the last century was telecommunications. The Bell system had enjoyed a monopoly in telephone service in the United States until its basic patents on the telephone expired in 1894, after which a wave of new competitors began providing phone service. The Bell system had concentrated on serving major cities and business customers, leaving many smaller communities unwired. Many of these independents extended service to the underserved communities, while others concentrated on competing with Bell in some major urban centers. By 1907, new entrants accounted for almost half the market. Service levels increased rapidly with this new competition: telephone penetration (measured as the number of phones per 100 people) rose from fewer than 2 in 1900 to more than 10 by 1916. Many of the new entrants adopted the latest innovation in telecommunications, automatic switching, much more quickly than the Bell system, which continued to rely upon operators to connect calls manually. Yet despite the advantages of this new switching technology, within a few years the number of independents began to decline. Faced with competitive pressure from the Bell system, most independents either failed, were acquired, or signed sublicensing agreements that allowed them to connect with the Bell system but limited their ability to compete with Bell.

The competitive failure of the independents was due at least in part to the Bell system's successful exploitation of the network dimension of telecommunications. The Bell system invested heavily in the technology and equipment needed to create a long-distance network. Although most customers at that time used the phone almost exclusively for local calls, businesses found the long-distance service very attractive. The independents tried but were unable to duplicate Bell's long-distance network connections, particularly in major urban areas where the Bell system had its largest networks, and where much of the long-distance business originated. Bell allowed the surviving independents to interconnect with its system, but only under the competition-restricting sublicensing agreements. Many independents chose this route, even though it meant signing away their own ability to expand and challenge Bell in the future.

In this case, the network characteristics of telecommunications proved critical to the competitive outcome. By providing long-distance services that its rivals were unable to duplicate, the Bell system was able to keep more people connected to its network and exploit economies of scale in long-distance service. But as it connected more users to its network, the Bell system also made it difficult for other companies to compete effectively. Without effective competition, the Bell system was in a position to limit service and set prices for that service at monopolistic levels.

Government policy toward these new technologies and new industries was as varied as the industries themselves. In the cases of telephones and electricity, government often chose to permit one monopoly provider to serve a geographic region but subjected the monopoly firm to rate regulation to prevent consumers from being overcharged. In part, this policy response reflected a view that some industries are "natural monopolies." In a natural monopoly, high fixed costs may make competition inefficient because a single provider could instead deliver service at the lowest possible cost. Also, in industries like the telephone industry, where demand-side network effects are important, previous attempts at competition had ultimately foundered as one dominant network emerged.

In other industries, however, competition seemed more effective at restraining market power, and government policy favored continued competition. In the case of automobiles, despite large economies of scale at individual plants, several producers were able to effectively compete in the large market pioneered by Ford, and policy intervention was unnecessary. In the oil industry, where combinations such as the Standard Oil trust threatened competition, government did intervene, but rather than establish a regulated monopoly, it used the antitrust laws to create more competition. These early policy responses shaped each of these industries during the years that followed, and these policies are still applied to some firms today. Just as the economy has changed over the last century, however, so, too, has the range of policy responses available to promote competition as an alternative to regulation, as discussed more fully below.

## Innovation and Change in the American Economy Today

Many of the same manufacturing industries that were just emerging at the beginning of the century continue to thrive, but new technologies and new processes are revitalizing these established industries and creating new ones. These innovations are taking place throughout the economy, and many involve both new technology and new ways of organizing the workplace.

Manufacturing industries remain dynamic and innovative, reflecting the pace of technological change. Manufacturers creating new products and processes account for about three-quarters of company-funded industrial R&D expenditure in the United States. Productivity growth in manufacturing also remains high, averaging 4.2 percent per year between 1993 and the third quarter of 1999, and these firms remain an important source of jobs for workers without college degrees. In an increasingly global economy, however, many manufacturing businesses have faced pressure to adapt to new ways of doing business in order to compete effectively with foreign companies.

One example is the "lean" production techniques first pioneered in the Japanese automobile industry. These methods, which involve redesigning the manufacturing process to eliminate waste and reduce the number of product defects, resulted in far lower costs and higher quality than traditional techniques in the U.S. automobile industry could achieve. Competition from Japanese and other foreign firms using these methods compelled U.S. automakers to focus on improving quality, and they have dramatically lowered costs and improved quality as a result.

Innovation in production technology has also changed the nature of the Nation's steel industry. Innovative U.S. minimill firms found that they could produce many steel products much more cheaply than could the traditional integrated mills by using electric arc furnace technology to recycle scrap steel and produce basic steel products. A U.S. minimill firm was also the first willing to gamble on constructing a full scale thin-slab caster using a foreign firm's technology. This new technology allowed minimills to compete in the large market for rolled sheet steel, used in such products as automobile body panels. U.S. companies using these new technologies are now offering increased competition to the traditional integrated mills; by the mid-1990s minimills accounted for close to 40 percent of U.S. steel production.

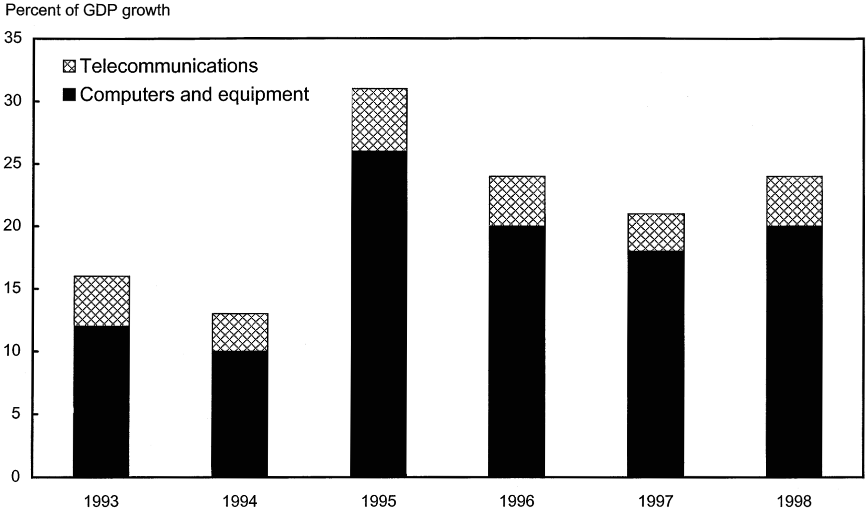
The pharmaceutical industry is one that is taking advantage of technological developments in biomedicine as well as in information technology. Traditionally, companies sifted through thousands of compounds to find those with desirable medical properties. Today's companies, in contrast, use a deeper understanding of human physiology that allows them to design, from the molecules up, drugs that target specific illnesses. The industry is also using the Internet to recruit patients for clinical trials of new drugs and to provide more complete and accessible information on new drugs to physicians.

Perhaps the most dramatic evidence of the economic impact of the information technology sector itself comes from the capital market, as reported in a recent study by a financial services company. According to the study, America's venture capital industry raised funds at a $25 billion annual rate in the first half of 1999, about two-thirds of which were placed in the information technology sector, and of that about three-quarters in Internet companies. In terms of market capitalization, the information technology hardware sector now accounts for about 14 percent of the U.S. total, versus 6 percent in 1989. The software component has expanded from about 2 percent in 1989 to around 9 percent today. Stocks in the Internet sector have a market value equal to around 4 percent of the total.

The importance of the information technology sector to the U.S. economy is not reflected in stock market valuations alone. The computer and telecommunications industries contributed between 21 and 31 percent of GDP growth in each of the years from 1995 to 1998 (Chart 3-2). And the contribution of these

Chart 3-2 **Contribution of Computers and Telecommunications Purchases to GDP Growth**

Spending on information technology has been a major source of GDP growth during the current expansion.




Source: Department of Commerce.

hardware-producing industries is only the tip of the iceberg. The bulk of employment today is in the private service-producing sectors, which also account for nearly two-thirds of GDP. Leading the growth in the service sectors have been a number of knowledge-based industries such as finance, insurance, and professional services (a category that includes business and legal services, among others). Measuring the contribution of these new services to GDP is important to developing an accurate picture of economic growth (Box 3-1).

In these knowledge-based industries, information technology has become increasingly important as a way to create new products and deliver them to customers. Broadly defined, information technology comprises technologies that process, store, and communicate information. For example, large U.S. banks now spend approximately 20 percent of their noninterest expense on information technology designed to integrate back office functions such as check processing with other functions such as customer service. Changes in information technology are transforming the economy by allowing people to communicate ideas and data in a variety of ways, from wireless phones to the Internet. The following sections examine several examples of this trend.

## Developments in Telecommunications

The telecommunications industry is an example of an older industry that the new information technologies have transformed. From its origins as a provider of simple voice telephony, this industry has evolved into a source of advanced infrastructure and sophisticated services that are essential to a host

**Box 3-1. Measuring the Economy in an Era of Technological Change**

Technological advances raise challenging measurement issues for government statisticians seeking to measure the size of the economy or its rate of growth. If technological improvements in the manufacturing process simply raised the quantity produced of a standard product (for example, the number of yards of a particular fabric type) from given inputs, there would be little problem—one could simply count the additional output. But many technological advances improve the quality of existing products or even create new ones (such as Internet services). The statistical challenges these advances present are enormous.

Existing statistical techniques do provide measures of some of the quality improvements and new products. For example, the GDP statistics incorporate adjustments for improvements in computing power when measuring real investment expenditure for producer's durable equipment. Similarly, when calculating the consumer price index, estimates of real expenditure on automobiles incorporate adjustments for improvements in the quality of new cars over time, reflecting changes, such as antilock brakes and airbags, that make cars safer and better.

In many industries, however, the measurement issues defy easy statistical solution. The field of medicine offers numerous examples of new drugs, devices, and treatments that have revolutionized care—for example, new techniques for treating heart attacks have raised patient survival rates; the development of an insulin pump has reduced the incidence of medical complications among diabetics, while raising their quality of life. Some of the most perplexing measurement problems involve industries that are heavy users of information technology, such as finance, insurance, and business services. The widespread introduction of automatic teller machines, for example, makes it possible to obtain banking services (mainly deposits or withdrawals) at any hour of the day or night—a service that was nearly impossible to obtain a few decades ago. And the mutual fund industry provides individual investors with diversification possibilities that would have been barely conceivable 30 years ago.

The widespread use of information technology for e-commerce poses especially complicated measurement problems. As more and more businesses across a range of industries—from services to manufacturing to retailing—use e-commerce for some components of their operations, it becomes increasingly difficult to account for what portion of a final product or service may have been changed or enhanced by the use of information technology.

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Box 3-1.—*continued*

These difficulties in measurement should not obscure the very real contribution that technological advances make to the economy. Government statistical agencies and others are therefore actively pursuing new measurement initiatives to better gauge and understand the impact of these changes.

of businesses from data processing to online publishing. Indeed, these changes in telecommunications have been just as important for these information providers as for the telecommunications industry itself, since, as discussed below, major telecommunications advances like the Internet are already having a major impact on how businesses do business.

These changes came about from a convergence of factors in which both technology and government regulatory policy played a part. Beginning with the Department of Justice's antitrust case and the resulting 1982 consent decree that divided the American Telephone and Telegraph Company into its local and long-distance components, prevailing government policy toward telecommunications regulation has focused on how to reduce barriers to competition for both traditional telephone service and emerging new services. To allow more competition in wireless service, portions of the radio spectrum were auctioned off, allowing new competitors to create their own networks in competition with incumbent cellular providers. Using provisions of the 1996 Telecommunications Act, new competitors in local phone markets have begun to negotiate interconnection agreements and to sell local telephone service in competition with the dominant incumbent local exchange carriers (Box 3-2). To encourage the regional Bell operating companies to make such entry possible, the Telecommunications Act required them to meet a list of conditions on opening their markets to new entrants before they were allowed to offer long-distance service in their own regions. In December 1999 the Federal Communications Commission found that one regional Bell company had met those conditions in New York.

The changes in the telecommunications industry that have resulted from these two developments—the emergence of new technologies and the new regulatory environment created by the 1996 Telecommunications Act—have been dramatic. Hundreds of new companies have entered all segments of the industry; the number of publicly held telecommunications companies alone nearly doubled over a recent 5-year period. These new competitors have been responsible for much of the recent growth in the local, long-distance, wireless, and equipment industries. Structural adjustments to this new competition have forced layoffs at some firms, yet the telephone service and equipment sectors are responsible for the net creation of approximately

**Box 3-2. Implementing Local Competition Provisions in the 1996 Telecommunications Act**

The Telecommunications Act of 1996 reduces barriers to entry in local telephone markets. To facilitate the entry of competitors into networks owned by incumbent local exchange carriers (ILECs), the act allows a requesting carrier to obtain access to the incumbent's network in any of three ways. It can purchase local service at wholesale rates for resale to end users, it can lease various (unbundled) elements of the incumbent's network needed for service, or it can interconnect its own facilities with the incumbent's network.

Six months after the 1996 act was passed, the Federal Communications Commission (FCC) issued its First Report and Order implementing the local-competition provisions. Thereafter, numerous ILECs as well as some state utility commissions challenged the rules, claiming that the FCC had exceeded its jurisdiction. In January 1999 the Supreme Court affirmed the FCC's role in providing a roadmap for competition.

The FCC continues to monitor the progress of competition with traditional ILECs, and its recent reports show that local competition, although still limited, is growing rapidly. Industry analysts also support this conclusion: one source finds that, by the middle of 1999, new entrants had increased their revenue market share to 6.3 percent of local revenue. The FCC's new orders on DSL-based services extend the process to this new technology by further clarifying which network elements competitors may access. This, too, should encourage local competition.

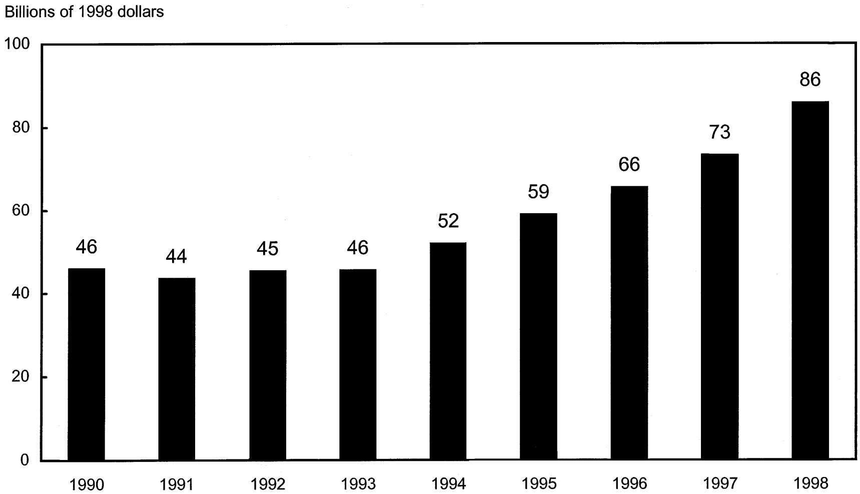
200,000 new jobs in 5 years. Both new and existing firms have invested tens of billions of dollars in facilities, services, and R&D. These investments in turn have led to increased network capacity, the deployment of new technology, and the rollout of advanced communications services.

These changes are particularly evident in the communications equipment industry, which has boomed in the last few years. Investment in communications equipment grew from $46 billion (in inflation-adjusted dollars) in 1993 to $86 billion per year in 1998—a 13 percent annual growth rate over 5 years (Chart 3-3). Some of that equipment is being used by the new providers of wireless services that are building out the systems made possible by the wireless spectrum auctions. By 1998, companies providing wireless telephony had invested more than $50 billion in new capital equipment, and wireless phones are now increasingly common, with more than 69 million Americans now subscribing to cellular service.

In addition to wireless services, demand for new equipment and fiber optic cable by new local providers of switched voice and high-speed data services like those used for accessing the Internet has spurred investment. These

Chart 3-3 **Real Private Direct Investment in Communications Equipment**

Between 1993 and 1998, investment in communications equipment grew an average of 13 percent a year.




Sources: Department of Commerce (Bureau of Economic Analysis), and Department of Labor (Bureau of Labor Statistics).

developments reflect dramatically declining costs for both data transmission and computing power. The cost of transmitting a single bit of data over a kilometer of fiber optic cable has fallen by three orders of magnitude since the mid-1970s. At the same time, the cost of information processing has fallen as more and more transistors can be packed onto a single semiconductor chip. As technology continues to advance, semiconductor manufacturers have been able to double the power of computer microprocessors every 18 months. Improvements in semiconductors and reduced costs for other components have helped account for the 20 to 30 percent annual decline in the quality-adjusted price of computers. With new innovations in semiconductor technology still coming onstream, the cost of information processing continues to plummet, increasing the capabilities of the information industry and expanding the market for information services.

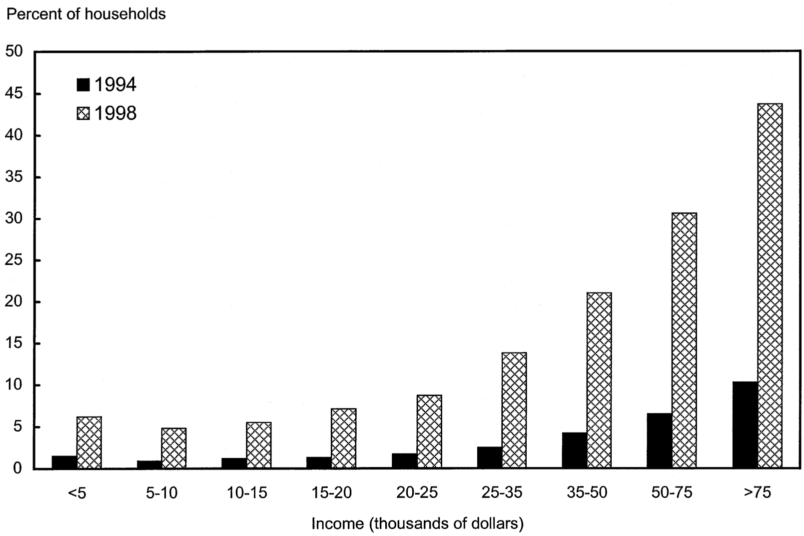
These falling prices have encouraged investment in the grid of telephone lines, cables, optical fibers, and signal processing and routing equipment that forms the backbone of the U.S. telecommunications infrastructure. The increasing public demand for fast and ready information has driven this backbone industry, motivating tremendous volumes of private investment. The growing demand for carrying capacity, or bandwidth, has led to investment in high-capacity fiber optic lines by telecommunications systems to meet the new infrastructure demands. The number of fiber-miles (the miles of sheathed fiber in a bundled cable times the number of fibers in the bundle) is one way to measure system capacity. By this measure, the total volume of fiber optic cable deployed by telecommunications carriers in the United States grew by about 16 percent in 1997, and by more than 21 percent in 1998, according to data from the Federal Communications Commission.

Consumer demand for telecommunications services is leading more and more American households to purchase additional telephone lines. Although some of these lines are used mostly for voice service, many are dedicated data lines. The number of additional lines more than doubled from 1993 to 1997, from 8.8 million to 17.9 million. This surge in growth mirrors the growth in American consumers' use of the Internet. In addition to extra phone lines, many residential users are beginning to purchase new high-speed broadband connections to the Internet being offered by phone and cable companies. For users who need to download large files, the speed of the connection can make an enormous difference in total transfer time. For example, a 10- to 20-minute digitized movie clip might take 10 megabytes of computer memory and require about 24 minutes to download with a 56-kilobit-per-second modem. By contrast, a cable modem or a high-speed digital subscriber line (DSL) connection offered by the phone company can download the same file in less than a minute. Rollout of these new services is just beginning: many phone companies are only now beginning to offer high-speed DSL connections in response to cable companies' offerings. By the end of the third quarter of 1999, cable modems were available to an estimated 37 million homes in North America, and approximately 1.4 million cable customers had signed up for the service. In contrast, only about 275,000 DSL lines were in service in the United States in October 1999. Deployment of DSL is expected to expand rapidly, however: as many as 2.1 million DSL lines may be in service by the end of 2000.

These investments are supporting the rapid growth of the Internet as it becomes a standard feature in American homes and workplaces. According to one survey, more than 118 million Americans had access to the Internet in November 1999, of whom more than 74 million were actively using the new medium. The use of e-mail at home has also risen sharply in the last few years, but this usage varies by income: more affluent Americans are much more likely to have e-mail access at home (Chart 3-4). This surge in connectivity has helped put the United States far in the lead in Internet use worldwide. The United States far surpasses Germany, Japan, or the United Kingdom in the number of Internet host computers per capita. Only Finland has a higher concentration than the United States, according to statistics compiled by the Organization for Economic Cooperation and Development (OECD). The OECD also found that the United States leads all other OECD member countries in the number per capita of web servers designed for electronic commerce. The combination of relatively

Chart 3-4 **Households with Access to E-Mail at Home, by Income**

Home access to e-mail rose sharply for all households between 1994 and 1998.




Source: Department of Commerce (National Telecommunications and Information Administration).

high penetration of personal computers among U.S. households and low Internet access costs in this country also has helped contribute to the greater success of electronic commerce here than in other countries. Internet access costs in the United States are much lower than in many other OECD countries (Table 3-1).

TABLE 3-1.—*Cost of Internet Access in 1999*

[U.S. dollars adjusted for purchasing power parities]

| Country | Cost for 40 hours |
|---|---|
| Canada | 31.45 |
| United States | 37.30 |
| Japan | 54.64 |
| Italy | 67.91 |
| Germany | 76.78 |
| France | 95.73 |
| United Kingdom | 105.61 |

Note.—Cost is for usage at peak times.

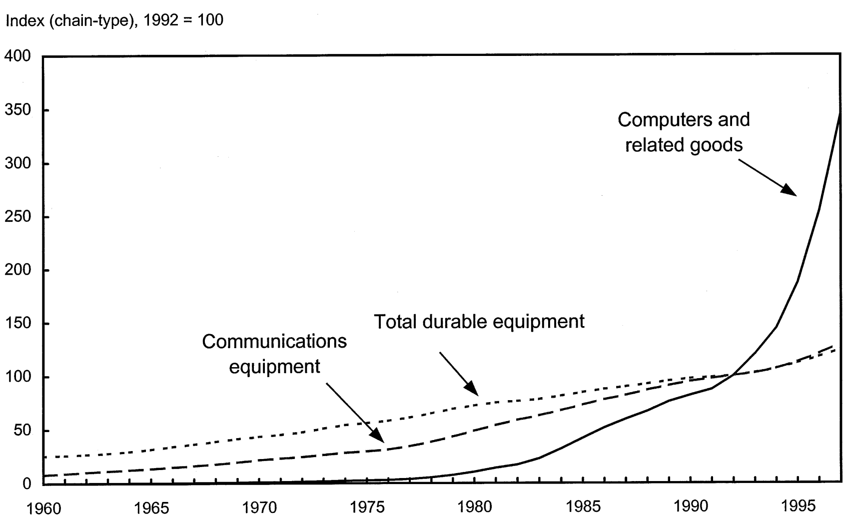
Source: Organization for Economic Cooperation and Development.

# How Information Technology Is Changing the Economy

In addition to providing a new communications medium, the Internet and its kindred technologies possess vast potential to enhance the economy's productivity and make firms more efficient. Much as Ford's assembly line concept had broad spillover effects beyond the automobile industry, so, too, the Internet and e-commerce are having broad effects throughout a number of industries. Many firms are investing aggressively in these technologies to speed the flow of important business information, internally as well as externally, and so raise productivity. Over the past 20 years, the real net stock of information technology equipment in the private sector has been rising steadily. The last 5 years have seen particularly sharp increases in the net stock of computers and related equipment relative to other durable equipment (Chart 3-5).

Even across industries that are making large investments in information technology, however, the amount of that investment per worker varies widely (Table 3-2). Telecommunications firms, nondepository financial institutions, and radio and TV broadcasting firms all invested more than $15,000 per worker in information technology equipment, according to 1996 data from the Department of Commerce. Other firms in industries that are also major investors, such as banks, insurance carriers, and railroads, invested between $4,000 and $6,000 per worker in information technology equipment.

Chart 3-5 **Real Net Stock of Information Technology Equipment in the Private Sector**
Investment in computers and related goods has grown far faster than other types of business investment in recent years.




Source: Department of Commerce (Bureau of Economic Analysis).

TABLE 3-2.—*Information Technology Investment per Worker in the 15 Most Information Technology-Intensive Industries, 1996*

[Dollars]

| Industry | Investment per worker |
|---|---|
| Telecommunications | 29,236 |
| Nondepository institutions | 18,129 |
| Pipelines, except natural gas | 18,069 |
| Radio and TV broadcasting | 17,512 |
| Electric, gas, and sanitary services | 9,728 |
| Petroleum and coal products | 8,102 |
| Real estate | 7,610 |
| Chemicals and allied products | 6,049 |
| Insurance carriers | 5,911 |
| Depository institutions | 5,897 |
| Holding and investment offices | 5,739 |
| Railroad transportation | 4,587 |
| Wholesale trade | 4,488 |
| Motion pictures | 4,225 |
| Electronic and other equipment | 3,511 |

Source: Department of Commerce.

As firms adopt these new technologies, they are also changing the definition of what constitutes a firm in today's economy. For some manufacturing firms, information technology offers new ways to integrate their suppliers more closely in the design and manufacturing of products. Even where the firms in the supply chain remain separate entities, the degree of cooperation may come to resemble what might occur in a vertically integrated firm. At the same time, other firms are finding that transactions that were once organized internally may now be better organized as market transactions, with competitive bidding even for specialized orders of custom-made parts.

At the retail level, the rise of the Internet has made possible the "virtual firm," which exists only to market goods through a website. With outside specialists available to handle details like filling orders, a firm can be run without the extensive supply infrastructure that many traditional brick-and-mortar firms have built. As companies grow larger, however, some have found that outsourcing important activities is not necessarily the best way to handle growing volumes of customers. Instead these firms are now investing in the same type of real-world infrastructure that their more traditional competitors have always used.

## Managing Information Flows

Information technology is having a major impact on how some firms organize their own internal operations. Investments in computer hardware like those described above often represent only a small portion of a company's total investment in information technology. Effective implementation of this technology also requires investing in the staff who will operate it, in developing specialized applications, and in user support. Cost surveys of firms in the services sector suggest that, at small, centralized sites, the costs of the staff required for operations and specialized software development may account for 74 percent of total costs, far exceeding the more visible expenditures the firm may make on hardware and prepackaged software. To develop the applications they need, many service firms are now conducting more of their own R&D, and this activity is beginning to show up in the aggregate R&D statistics. Whereas in 1987 nonmanufacturing industries accounted for only about 8 percent of non-Federal R&D funds, by 1995 that figure was 25 percent. These investments have been concentrated in computer programming and data processing services, in wholesale and retail trade, in communications services, and in research, development, and testing services.

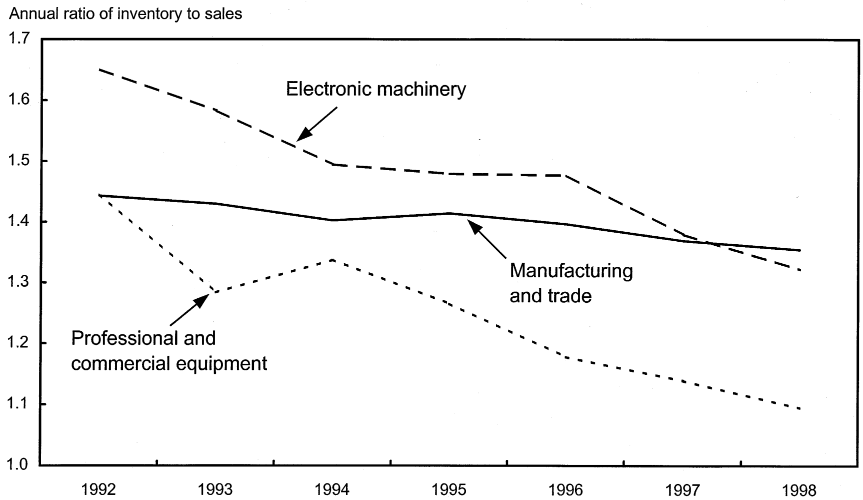
One area in which information technology can enhance productivity is the management of inventories. For example, electronic scanners have been a familiar sight in grocery checkout lines for some time, but some retailers have begun to adopt new and more efficient distribution methods that rely on these scanners and the wealth of transactions data they can provide. One large retailer with a chain of grocery superstores has used information technology to track what is selling in its stores and to use that information to build a more efficient distribution system. This firm uses its buying power to generate large orders to manufacturers, which then deliver the demanded goods to the firm's warehouse distribution centers. Those centers, in turn, are responsible for resupplying the individual retail stores. To keep revenue high and costs low, the firm also analyzes its scanner data on sales to maximize the use of its shelf space. Detailed information captured by scanners at each store track how fast products are selling, so that stores can be resupplied at frequent intervals from the distribution centers. This avoids the need to keep large and expensive inventories at the stores themselves. In total, this company has reduced its operating costs to a mere 17.5 percent of sales, compared with 22 percent for a traditional supermarket.

The increased investment in information technology by companies has coincided with a reduction in the economy-wide ratio of inventories to sales during the current economic expansion (Chart 3-6). Although, to be sure, information technology is used in many areas besides inventory management, some of those investments may have helped businesses to better manage inventory growth and improve productivity during the current expansion.

Information technology is also being used to better manage information flows between firms, such as between a final-goods manufacturer and the different levels of its supplier chain. In the automobile industry, for example, one recent report notes that companies have largely replaced paper drawings

Chart 3-6 **Real Inventory-to-Sales Ratios for Selected Product Categories**

Businesses require smaller inventories to support a given volume of sales today than they did just a few years ago.




Source: Department of Commerce (Bureau of Economic Analysis).

with digital representations as a means of storing, analyzing, and communicating data on products and parts. One original equipment manufacturer estimated that it exchanges product data both within the company and with its suppliers as many as 453,000 times a year.

## Retail E-Commerce

Information technology is having an impact on how businesses do business in yet another way, through the growing use of the Internet by firms as a communications tool. The Internet is already revolutionizing distribution technology at both the retail and the wholesale level. With millions of people now online, the potential to use the Internet as a low-cost means to communicate information to customers and receive orders for products is growing ever larger. At the retail level, new firms are springing up to market a whole range of consumer products from books and music CDs to cars. E-commerce retailing has several potential advantages over traditional retailing, some of which it shares with traditional mail-order firms. Like a mail-order firm, a firm with a website may be able to offer more products online than a traditional brick-and-mortar store, because it is far less limited by shelf space constraints. It can make extensive product information available to interested customers around the country and the world, who can then make their selections automatically, without the need for a salesperson.

For e-retailers, the Internet replaces paper catalogs as the medium used to distribute information to customers, but these retailers still face some of the same challenges as traditional catalog and storefront retailers in delivering the goods. In response, some large electronic retailers have now begun building their own warehouse distribution centers, providing a real infrastructure to complement their virtual one. At present, the Internet is so new that no one can predict which business strategies and which retailers will succeed in the new medium. Many Internet retailers continue to lose money as they build their businesses and strive for the economies of scale needed to survive in a marketplace shared with both other Internet rivals and traditional competitors.

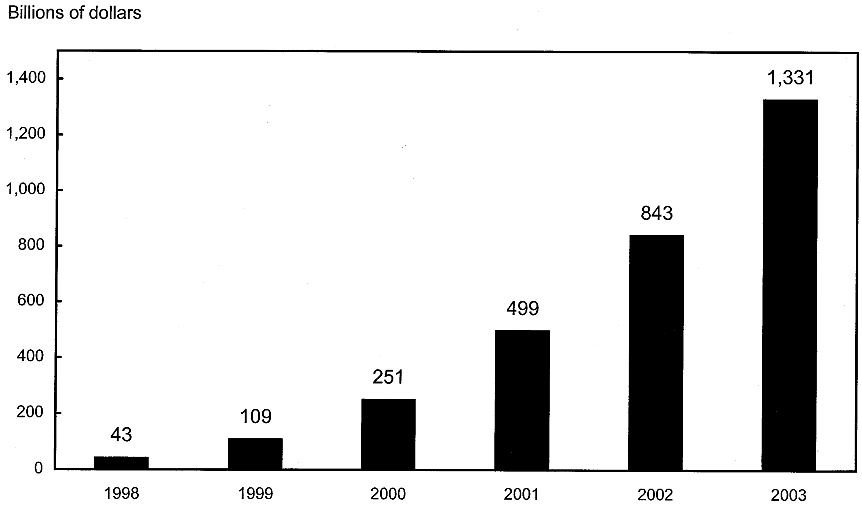
Unfortunately, despite a proliferation of anecdotes, hard data on the importance of e-commerce and the digital economy more generally remain scant. This lack of appropriate data hampers analysis of the impact of the digitization of the economy. For example, it is not currently possible to separate out e-commerce activities from other types of commercial activities in the statistical series produced by the Federal Government. Data specific to e-commerce currently come, for the most part, from market research firms, which use divergent definitions and methodologies. To address this problem, major Federal statistical agencies (the Bureau of Economic Analysis, the Bureau of the Census, and the Bureau of Labor Standards) are working together to formulate an e-commerce initiative that will help ensure that official government statistics accurately reflect the new digital economy.

Using private data for 1998, estimates of the value of online retailing range from $7 billion to $15 billion; even taking the high end of this range, e-commerce would account for only about 0.5 percent of retail sales. In one 1998 survey, however, nearly half of households with Internet access had made online purchases within 6 months of the survey.  In addition, a much larger quantity of sales is influenced in some way by the Internet. For example, many consumers research their purchases, such as automobiles or books, online before buying them offline, through traditional outlets. By one estimate, roughly $50 billion in offline retail sales was influenced by the Internet in 1998.

## Business-to-Business E-Commerce

The Internet plays a significant role today in providing new distribution channels for wholesale transactions between businesses. By one estimate, business-to-business e-commerce is expected to grow from $43 billion in 1998 to over $1.3 trillion by 2003 (Chart 3-7). Using the World Wide Web, companies can automate the order process and reduce costs. One major supplier of computer components had routinely been receiving orders by phone or facsimile from several hundred customers all over the world. Processing these orders was cumbersome, and moving several hundred of these

Chart 3-7 **Business-to-Business E-Commerce**
The value of business-to-business e-commerce is projected to rise severalfold over the next few years.




Source: Forrester Research, Inc.

customers to a web-based solution promised to improve customer service and give managers better access to information on the status of orders. The company built a website targeted to these customers and soon was able to move $1 billion in orders per month online.

Another firm that sells networking hardware also uses the Internet to reduce its costs. Many of the company's products are built to order from customers' specifications. The firm routinely checks those specifications to make sure the product will work as configured, but it found that nearly one in four orders taken by phone, fax, or e-mail contained errors that caused the order to be rejected or required additional customer contact. After moving the process of configuration and pricing online, the company now reports that 98 percent of orders pass through the system without an error, saving both the company and its customers valuable time and expense. Across all its operations, having moved more of its technical support and marketing functions online, the company estimates that it now saves more than $300 million per year in operating costs.

Business-to-business e-commerce is also resulting in new and more competitive markets. The Internet's size and reach have created deeper markets, with larger pools of both buyers and sellers, for many basic commodities. Where before specialized brokers were needed to match buyers and sellers in transactions, new websites today allow multiple buyers and sellers to find each other and enter into transactions quickly and efficiently. In the steel industry, for example, the electronic equivalent of a spot market now matches customers and suppliers for surplus quantities of steel of various types. One firm that provides such a virtual marketplace for transactions in this industry has seen both the number of suppliers and the volume of product offered on its site expand substantially. In just one year, offerings on the site rose from about 20,000 tons a month to over 120,000 tons.

Purchasing managers are also using information technology to actively manage and reduce their firms' procurement costs by changing traditional relationships between the firm and its suppliers. For example, many manufacturers buy custom-made materials that they incorporate into finished products. Because these materials are often made to buyers' specifications, there are no catalogs or price lists to allow buyers to make price comparisons. Fragmented supply markets and the importance of product quality in supplier selection also make purchasing difficult. Concerns about the quality of new suppliers' products, for example, may cause a firm to rely instead on existing suppliers that are known quantities. One company achieves significant cost savings for the purchasing managers who are its clients by using electronic bidding technology to conduct auctions among alternative suppliers of a whole range of inputs. The company has organized auctions for goods ranging from printed circuit boards to injection-molded plastic parts (Box 3-3).

Although this firm's electronic auction software is an example of information technology at work, an important part of the service that the firm provides is a detailed, specific analysis of the desired components, followed by an extensive search for potential suppliers. In addition to the traditional suppliers that a firm has relied on in the past, the auction firm may find that other suppliers around the world can produce the demanded good as well. Working with the buyer, the company screens these firms to determine whether they are capable of producing the good that meets the buyer's specific needs. This use of information technology to cast a wider net poses both challenges and opportunities for suppliers. For efficient firms, it offers a way to compete for business they might not have been able to bid on previously. But existing suppliers must compete more aggressively than ever before if they wish to retain or expand their business in an increasingly global economy.

## Information Technology and the Theory of the Firm

These developments in information technology raise a number of questions about the organization of firms in a market economy. Information technology has the potential to dramatically lower the cost of acquiring and disseminating information of significant value to firms and their customers. Using various types of information technology, firms can convey information about products to potential customers, obtain more detailed and targeted market data about customers and their needs, and then sell products to more customers. But how will lower costs of communication affect the structure of

**Box 3-3. Holding an Online Auction**

An online auction specialist allows corporate buyers to lower their procurement costs by providing the technology and support for computerized auctions. Rather than sending out a paper request for proposals and obtaining a single bid from each potential contractor, buyers holding online auctions can allow bidders to observe how their bids compare with those of their peers. To generate more competition, however, the auction specialist does more than simply provide a connection for the client firm's existing suppliers. The auction specialist also searches out new potential suppliers that meet the buyer's specifications.

In one such auction for printed circuit boards, the auction specialist first identified 29 bidders in North America, Asia, and Europe. Eight of the firms had done business with the buyer before, but the remainder had not. Each supplier was linked electronically to the auction firm's computer server, so that it could submit bids online, observe the bids placed by its competitors, and then decide whether to submit a new, lower bid of its own. Within 5 minutes after the auction opened, the bids received for the circuit board contract quickly dropped to 18 percent below the buyer's historical average cost for such goods. As the auction's closing time approached, more and more bids were submitted. By the time the auction had concluded, after about 1 hour, three bidders had submitted virtually identical low bids, and the buyer was able to reduce its expected cost by 42 percent, or $6.4 million.

the firm itself? When information is less costly to communicate, some firms may decide to expand their operations to exploit greater economies of scope in selling different products. Alternatively, other firms may find that, with more customers for what had previously been low-volume markets, it is more profitable to specialize, seeking lower production costs through greater economies of scale. The evolving nature of the new technology makes it hard to predict which effect will predominate, and the answers could easily vary across different lines of business.

Information technology may also have far-reaching implications for the structure of firms if it changes the sources of competitive advantage in the markets where they conduct business. Using the new information and communications technologies, firms have greater potential to respond quickly and more flexibly to challenges posed by changing circumstances. Older sources of competitive advantage, such as established distribution networks, may now seem outdated and unnecessary in light of new communications tools like the Internet. By eliminating middlemen from the distribution network, a firm can cut its costs while still serving its customers.

However, the same technology that disintermediates some actors in the economic chain between producers and consumers is also opening up new opportunities for other firms that can effectively add value in a different way. The auction firm that finds new suppliers, for example, replaces an internal procurement decision process with a market-based specialist. As firms continue to restructure themselves to take advantage of these new opportunities, they may find it worthwhile to expand or contract their activities to focus on those where they add the most value to the economic chain.

## Information Technology and Network Effects

As new types of information technology link together computers, telephones, and other types of communications devices, network effects become increasingly important in determining the success or failure of some products. In industries not subject to network effects, the total value of a product is simply the sum of its value to each user; adding more users increases the total value only by the product's value to the new users. But in industries where network effects are present, such as telephone or Internet service, the value of the product to each user, including the existing users, rises as the total number of users rises. In the case of a phone network, for example, each person is connected to the network by a wire (or a wireless) link. The more links the network has, the more valuable it is to each participant in the network, because the network can be used to contact more people. This type of network effect, also called a network externality, creates a cycle of positive feedback in a growing network. As more people join the network, it becomes more attractive to potential new members, and the network increases in size, continuing the cycle. The same network effects that create positive feedback in a growing network, however, can work against a network that is shrinking. As a network shrinks, it becomes less valuable to members, and more members leave, causing the network's value to spiral downward.

Markets with strong network effects are referred to as "tippy," because they can tip in favor of one firm or another, depending upon which firm is able to generate enough positive feedback to win the allegiance of a sizable majority of consumers. The winning firm in such a market then becomes the dominant network and may be in a position to establish a de facto standard for the industry. Firms engaged in such a "standards war" may even choose to give their product away initially if doing so increases the firm's likelihood that it will own the dominant technology. Once a firm wins the standards war, consumers' switching costs may well be high enough that the firm can exercise market power to earn above-normal profits.

As the history of the Bell system at the beginning of the century demonstrates, network effects can have a dramatic impact on market outcomes when one network becomes very large relative to its competitors.

Using its size and its superior long-distance service, the Bell system became the dominant firm in areas of the country where it had once competed with independent phone companies. To convince consumers to sign up for its service over those of the independents, the Bell system advertised the advantages of its larger number of connections. By refusing to interconnect with competing systems, the Bell system was able to exploit the advantage of its large network to the detriment of its competitors.

Establishing a new network in an industry with strong network externalities can be very difficult, because users of the existing network may have to incur costs to move to the new network. In some cases, such as the software industry or the computer networking equipment industry, these switching costs may include major investments in equipment and training to use the new network. An even larger cost for users of the new network, however, may be that imposed by the lack of connections with the incumbent network.

These switching costs, however, do not necessarily allow the incumbent firm to rest on its laurels. A new network can supplant an established network in certain circumstances. One advantage a new network may have is that its new technology may simply work better for some applications than the established network's technology. Where the old network may have to worry about compatibility with existing standards, a new provider can start from scratch and take advantage of technological developments to create a better product. With a superior technology, a new network provider may be able to convince some users to incur the switching costs because the advantages of the new technology are large enough to make it worthwhile even if users cannot connect easily with the old network. Once it has established a niche market among these users, the provider can then seek to expand the use of its network to more mainstream customers. The computer industry, for example, has seen several waves of technology go beyond an existing dominant standard, and each of those waves in turn developed into its own standard. Early computer technology was dominated by mainframes, but mainframes were later supplanted by minicomputers for many uses, and by personal computers for still more uses. In each case the new technology started out not by directly challenging the incumbent, but by appealing to a group of users not well served by the existing technology.

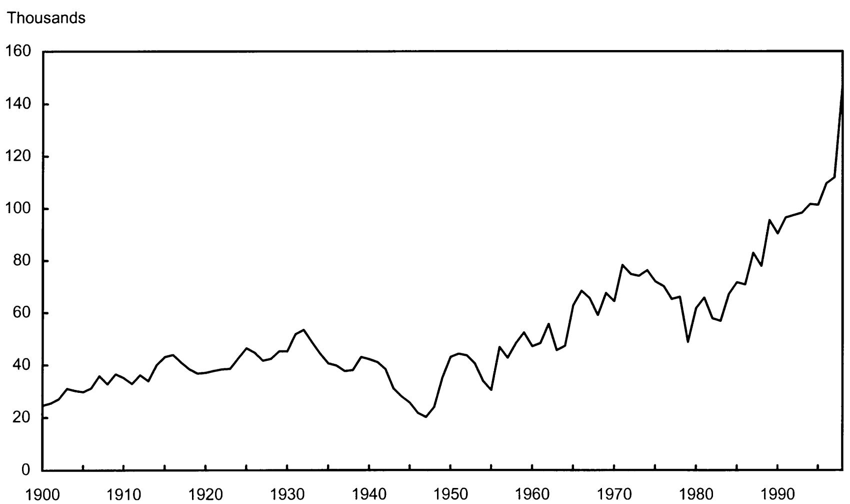
As information technology advances, the economic effects of new data and communications networks will become increasingly important. The Internet provides a model for how those networks can work together. The Internet can be described as a "network of networks" held together by a standard communications protocol. The hardware and software running any individual local network may be completely incompatible with the hardware and software running a different local network, but with a standard communications protocol the two networks can talk to each other. This increases the value of each network to its users. Where these new technologies will take us in the 21st century will only become evident over time, but by encouraging connections between networks, government and the private sector can work together to provide a strong platform on which new ideas and new technologies can grow.

## The Role for Government Policies

We have seen how firms in a range of industries are now realizing some of the productivity gains that recent advances in information technology have promised. For its part, this Administration remains committed to a policy that encourages innovation and competition in the private sector to the fullest extent possible. One element of that policy is establishing the rules for protecting intellectual property rights to new products through patents. Although patents have been used to protect the property rights of inventors in their inventions since the founding of the Republic, the last several years have seen an explosion in the number of patents granted in the United States (Chart 3-8). Several hypotheses have been advanced to explain this surge in patent grants, including the possibility that it reflects today's rapid pace of technological discovery. A recent court ruling clearly indicating the patentability of computer software may also have encouraged the patent surge.

Chart 3-8 **Patents Granted Since 1900**

Since 1995, patent grants in the United States have increased at a historically unprecedented rate.




Source: Department of Commerce (Patent and Trademark Office).

Intellectual property rights in works of authorship, including those disseminated through the Internet, are protected through copyright. The Administration has worked to set up a legal framework for electronic contracting and has supported protection of intellectual property rights in the digital environment. In the latter area, the Administration has supported initiatives to ensure that copyrighted works are adequately protected on the Internet. Information in the form of software, texts, music, and audiovisuals is increasingly important to the economy, and all these media can be efficiently delivered over the Internet. Without legal protections commensurate to those enjoyed by distributors of physical media, intellectual property owners might choose not to make their works available in the digital environment. The Administration has also been active in advocating the development of international standards for the protection of copyrights on the Internet and in promoting a balanced approach to protecting data bases.

## Support for Research and Development

Maintaining and increasing the flow of innovative ideas to the economy also require continuing efforts in R&D to create new products and services. Over the last several years, private industry has continued to expand its funding of R&D, but many of these efforts are focused on the development required to bring new products to market. To fill in the gaps in private R&D efforts, government must go a step beyond encouraging private innovation and competition. By supporting both the basic and the applied research necessary to create new technologies yet unimagined, government can act as a catalyst for growth in the American economy in this new century.

In supporting R&D, the objective of government policy is to identify projects with large potential spillover benefits to the economy. Funding basic and applied research is one way to accomplish this objective because it expands the knowledge base of society. Although this research can generate large payoffs in the form of new technologies, the private sector is unlikely on its own to provide the amount of research, basic or applied, that is best for society. Firms may underinvest in research because the social benefits from the innovations they might make exceed the payoff that the firm itself can capture with traditional mechanisms such as patents and protection of trade secrets. Some of the most innovative ideas that research might generate may not immediately result in commercially useful products or methods; they may require an extended period of further development before that can happen, and often companies may not want to wait that long. Hence government support for basic research is critical in a knowledge-based economy, where growth ultimately depends upon the flow of new ideas.

This problem seems particularly vexing for what are sometimes called general-purpose technologies (GPTs). A GPT is a technology that may have many possible uses but that depends on the development of complementary innovations for those uses to be exploited. For example, an ordinary desktop computer can be put to a vast number of different uses, but all require complementary investment in software. Until a ready store of such complementary innovations is available, a GPT may not be very useful, and its creators may have limited incentive to make improvements in the technology. As these complementary innovations occur, however, the gains from further innovation to improve the GPT itself increase. And in turn, as the GPT is improved, the gains from creating still more complementary innovations rise, these innovations then appear, and so on in a virtuous cycle. Jumpstarting this virtuous cycle may be difficult, however, when the commercial gain appears to be low. In such circumstances, government can again play an important role by providing the initial funding for new technologies that still need more basic research.

The Internet itself is a GPT that developed in just this way. For all the considerable excitement today about its commercial potential, the Internet did not start out as a commercial project at all, but as a way to interconnect government computers at different sites to share information and data. At its creation in 1969 under a U.S. Department of Defense project, the predecessor to the Internet (then known as ARPANET) consisted of just four nodes at different locations. Over time, more nodes and more users were added, until eventually the National Science Foundation (NSF) took over the primary role in funding what by then had become the Internet. With the introduction of the World Wide Web by the European Center for Particle Research in 1989, and of a graphical user interface called Mosaic by the NSF's National Center for Supercomputing Applications in 1993, the Internet took a giant step further. From a tool used by a relatively small number of government workers and academics, it was transformed into a widely accessible public communications medium, and usage increased dramatically. As the number of users expanded, commercial development began and government sponsorship became unnecessary.

## Technology Initiatives in the Budget

The Administration is committed to maintaining strong support for R&D efforts in a wide variety of areas. The centerpiece of this commitment is the 21st Century Research Fund, which aims at ensuring stability and growth for the Nation's highest priority research programs. In the President's budget for 2001, approximately $43 billion has been committed to science and technology endeavors through this fund, a 7 percent increase over the previous year. Through the fund, the Administration seeks to finance a broad and balanced national R&D portfolio to ensure that technological advancements continue to be made in areas of the economy where they are needed. Having a balanced R&D portfolio is necessary because advances in one discipline may depend upon research gains in separate fields.

A number of programs undertaken by the 21st Century Research Fund are designed to leverage Federal R&D investments through partnerships with firms in the private sector. For example, the Partnership for a New Generation of Vehicles seeks to develop less polluting, more fuel-efficient technologies for cars by combining the research efforts of Federal Government laboratories with those of the major U.S. automakers. The Advanced Technology Program, administered by the National Institute of Standards and Technology, is another example of the Administration's efforts to encourage public-private partnerships in R&D. This program provides funding for scientific and technical projects that may offer substantial economic returns to the United States.

This year's budget also proposes a multiagency National Nanotechnology Initiative that increases the level of funding for nanotechnology research in 2001 by more than 80 percent, to nearly $500 million. The initiative focuses on the manipulation of matter at the atomic and molecular levels, offering an unprecedented chance to study new properties, processes, and phenomena that matter exhibits at a scale between atoms and molecules. The initiative hopes to culminate in technologies with the unprecedented ability to create new classes of devices as small as or smaller than a human cell. This research could lead to continued improvement in electronics and electro-optics for information technology; to higher performance, lower maintenance materials for manufacturing, defense, space, and environmental applications; and to accelerated biotechnical applications in medicine, health care, and agriculture. The results of this effort could be as significant to our economy as the development of the transistor and the Internet.

This year's budget also increases support for information technology R&D from $1.7 billion to $2.3 billion. This program funds the fundamental research in computer science that is expected to lead to major breakthroughs in the next generation of supercomputers, networks, software, and applications. This ongoing work includes the Next Generation Internet Initiative, which is connecting universities and national laboratories with high-speed networks that are 100 to 1,000 times faster than today's Internet. R&D in information technology also funds development of extremely powerful supercomputers for applications in a variety of fields. Long-term research under this program's umbrella will create high-technology, high-wage jobs and will improve our quality of life. All of these projects serve as examples of how a small investment today may yield significant benefits in the years to come.

## Maintaining Competition

Another way in which government policy can encourage economic growth is through reducing barriers to competition and entry rather than imposing restrictions that in effect protect incumbent firms. For example, by making more of the electromagnetic spectrum available for wireless services, as discussed above, the Federal Government has enabled a number of new firms to enter the market for these services. The prices that consumers pay for wireless phone service have dropped, on average, as a result. In designing the spectrum auctions, the Federal Communications Commission was careful to limit the ability of existing cellular incumbents to acquire the lion's share of spectrum available, and this laid the necessary foundation for more competition between competing wireless networks. Similarly, the Telecommunications Act of 1996 removed barriers to entry across telecommunications markets, and it set conditions for regional Bell operating companies to enter long-distance markets after making changes to permit the entry of new competitors for local telephone services. In December 1999, the commission found that one company had met those conditions in New York State and allowed it to begin offering long-distance service in New York. Companies in other States are expected to qualify in the future as more local markets are opened to competition for both business and residential customers.

Vigorously enforcing the Nation's antitrust laws is another important element of a policy that promotes competition. As noted above, concerns about the competitive implications of mergers are not new, but the recent wave of large mergers has highlighted this aspect of antitrust policy. One reason for this merger activity is that firms are seeking to achieve efficiencies and become more competitive in the global marketplace. The vast majority of these mergers pose no competitive concern because they do not combine two significant competitors in a market that would raise a concern about diminished competition. In other cases, however, the antitrust agencies at the Department of Justice and the Federal Trade Commission have opposed elements of planned mergers that would have diminished competition in several cases, including gasoline marketing and refining, grain distribution, avionics, waste disposal, banking services, and mobile telephony. In these cases the antitrust agencies have opposed mergers because of their potentially adverse impact on consumers and have sought divestitures that would preserve competition.

In analyzing mergers and other potentially anticompetitive conduct, antitrust agencies increasingly must consider the effects that arise not only from traditional economies of scale in production, but also from the effects of market power created by network effects. For some products—for example, some types of basic computer software and hardware—having a large installed base of users creates a de facto standard both for those users and for product developers, who must use that standard to create new, complementary products. Users accustomed to using a particular standard may have built up a large investment in knowledge and complementary products of their own that makes switching to any alternative, nonstandard product costly. Users also may be reluctant to switch when alternatives to the prevailing standard do not have enough developers creating the complementary products that would enhance the value of the basic product. In these circumstances, a company that controls a standard might use that market power to prevent other products from gaining the critical mass of users that would enable them to challenge the standard and undermine its market power. Antitrust agencies vigorously enforce the antitrust laws to preserve competition and eliminate unreasonably exclusionary practices related to standards.

For completely new areas of economic activity such as e-commerce, the Administration believes that growth can best be encouraged by limiting the regulatory burden. Regulatory forbearance and policies that let nascent markets grow have encouraged continuing investment in information infrastructure and made possible unprecedented growth in the development, adoption, and use of e-commerce. As one example, the Administration has successfully opposed the imposition of discriminatory taxes on Internet activity: the Internet Tax Freedom Act establishes a 3-year moratorium on new and discriminatory taxes on electronic commerce.

Finally, all policies that rely on the private sector to provide valuable new technologies or other innovations face a common challenge, namely, that of ensuring that all members of society benefit from those technologies and those innovations. Evidence is growing of a "digital divide," in which some racial, ethnic, and income groups in the United States use the Internet less than others. Created under the Telecommunications Act of 1996, the E-rate program for wiring schools and public libraries is an important means of increasing the diffusion of Internet use and ensuring that access to information is widely available (see Chapter 4). The discounts available under this program have allowed more than 1 million classrooms to be connected to the Internet. This policy, along with others discussed in the following chapter, will help Americans develop the skills they need to participate in an increasingly information-driven economy.

## Conclusion

Recent developments in technology and regulation underscore the vital role that government has to play in ensuring the foundations for a growing economy and a vibrant private sector. By providing support for basic and applied research, government can act as a catalyst for new innovations and new technologies that may someday prove critical in maintaining America's technological lead in an increasingly information-dependent world.

Similarly, by reducing barriers to competition wherever possible, the regulatory environment that government creates can encourage the birth of new services that will lead to continued growth, while ensuring that all Americans have the opportunity to benefit. The dramatic changes in the American economy over the last century should remind us that future changes, still unpredictable, are sure to follow, creating new challenges and opportunities during the century that has just begun. If government continues to encourage firms and workers to meet those challenges, America can maintain a strong, yet flexible economy that fosters growth and provides opportunity for all its citizens for many years to come.